REQUEST FOR A SPECIAL PROJECT 2022–2024

MEMBER STATE:	SPAIN
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Project Title:	SIMULATIONS OF TROPICAL TRANSITIONS IN THE EASTERN NORTH-ATLANTIC OCEAN: PAST, PRESENT AND FUTURE PROJECTIONS

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2022	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2022-2024: (To make changes to an existing project please submit an amended version of the original form.)		**2022**	**2023**	**2024**
High Performance Computing Facility	(SBU)	2000000	7917382	8000000
Accumulated data storage (total archive volume)[2]	(GB)	25000	25000	25000

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[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.

[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.

Continue overleaf

Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF as well as the Scientific Advisory Committee. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests asking for 3,000,000 SBUs or more should be more detailed (3-5 pages). Large requests asking for 10,000,000 SBUs or more might receive a detailed review by members of the Scientific Advisory Committee.

In the current special project, a continuation of the work started in the project SPESMART is developed. In this new project, anomalous tropical cyclones (TCs), that have followed unusual tracks near Western Europe, will be studied. Hurricane Vince (Tapiador et al., 2007; Beven et al., 2008), and Tropical Storm Delta in 2005 (Beven et al., 2008), Hurricane Alex in 2016, Hurricane Ophelia in 2017, or recently Hurricane Leslie in October 2018 have affected different European domains. Their intensification after the extratropical transition (Evans and Hart, 2003) have caused injuries, casualties and huge economical losses along their tracks. Therefore, the analysis of these systems has become one of the most important studies on the domain of the Eastern North Atlantic (ENA).

The abovementioned storms have shown that they have in common similar formation and transition; In fact, they formed through the so-called Tropical Transition (TT) process, a recently "discovered" form of tropical cyclogenesis. One of the purposes of the present special project will be the study and characterization of these systems, analysing their genesis and, at the same time, trying to understand their essential atmospheric dynamics. The process by which a baroclinic EC is transformed into a fully warm-core TC is known as TT (Davis and Bosart, 2003). TCs formed via TT have the highest likelihood of affecting Europe, because they occur in the subtropics and midlatitudes. TTs form more frequently over the western North Atlantic Ocean, being less common over the Eastern one as the environmental conditions for their formation or maintenance are marginal over the latter. Sea surface temperatures in ENA are lower than over the Western one at the same latitudes, the vertical wind shear is generally high, and during summer, the subsidence associated to the descending branch of the Hadley circulation creates stable and dry conditions. However, during autumn and winter these regions change their conditions and can be occasionally affected by TTs. TTs not only can form in-situ over ENA, but those forming over the Western one can also enter the ENA driven by a westerly large-scale steering flow.

Although some works have studied TTs, numerous questions are still open. For instance, an improved insight into the relationship between convective processes and the PV streamers throughout the pre-development phase of the disturbance life cycle is needed, which can only be undertaken with higher-resolution simulations. In addition, the role played by warm seclusions (Shapiro and Keyser, 1990) in the development of TTs is not clear yet and how to differentiate between each other (Hulme and Martin, 2009) keeps being a challenge. Another potential field which needs attention is the analysis of the uncertainty, and what can possibly cause it. Its relevance is clearly reflected in the forecast of these events (e.g. Leslie). It is also worth analysing the effect of the Anthropogenic Climate Change (ACC) is playing any role in development and possible increase of TTs.

GENERAL OBJECTIVES AND SPECIFIC TASKS

In the original project request, the general objectives and specific tasks were mentioned. Objectives related to the TT selection in ENA in a reanalysis database of enough high resolution, such as the ERA-5 reanalysis, the development of TTs, and their relationship with PV streamers and midlatitude dynamics from climate perspective, and simulations of selected TTs using both HARMONIE and WRF models to gain insight into how these events and the relationship between TT development and ACC are mentioned.

A description of the different phases and tasks of the project, as well as the used methodology are also indicated, highlighting four phases, of which The two first phases are already carried out.

PHASE 1: Selection of TTs in ENA: study of the genesis and atmospheric dynamic.

PHASE 2: Assessment of the skill of the models in simulating the behavior of TTs. Study the atmospheric dynamic of TTs.

In the progress report, we have detailed the advances of the objectives included in the original request. The phases 3 and 4 related to Analysis of TTs in simulations of an advanced climate model (**PHASE 3**) and Analysis of TTs in future ACC projections (**PHASE 4**) are being developed in this moment. To do this, future TTs have to be selected and a subset of them will be simulated with HARMONIE and WRF nested in EC-Earth projections.

COMPUTER RESOURCES AND TECHNICAL CHARACTERISTICS OF THE CODE

The WRF numerical model for analysing TTs will be configured with two domains: the outer domain with 7.5 km of grid resolution and the high resolution one with 2.5 km (Figure 2), using 1000 grid points in the west-east direction, 1000 grid points in the south-north direction and 65 sigma levels unequally spaced, with a greater number of levels in the lower troposphere for a better representation of the convective planetary boundary-layer processes. Adaptative time steps are used. The WRF physics options used in this study are those defined as the default for Hurricane research mode. Among them, it is worth noting the WRF Single-Moment 6-class (WSM6) (Hong and Lim, 2006) parameterization scheme for microphysics, YSU for the planetary boundary layer (PBL), and Dudhia (Dudhia, 1989) and RRTM for short and longwave radiation, respectively. No cumulus parameterization scheme is used in this study, being cloudiness explicitly computed by the model. Iinitial/boundary conditions will be obtained from the ERA5 Reanalysis of the ECMWF with 0.31° horizontal resolution every 6 hours.

On the other hand, the HARMONIE model configuration (v40h1.1.1 and 43h2.1 versions) has been used to simulate and study the TTs. The final set up used to simulate TTs resembles WRF's one as much as possible to maintain the consistency of the study. Defined with the HARMONIE default physics options (Bengtsson et al., 2017), the model also has a main domain with 2.5 km resolution and the same grid dimensions (1000 x 1000) in the west-east and south-north directions (domain in Figure 3) with 65 hybrid sigma-pressure levels in the vertical. The initial/boundary conditions are the same as those used for WRF. In this case, the model is configured with a temporal resolution of 75 s (Bengtsson et al., 2017). Operated at 2.5 km resolution this model has a convection-permitting configuration and uses a non-hydrostatic spectral dynamical core with a semi-Lagrangian and semi-implicit discretization of the equations. In this way, more realistic results are obtained (Bengtsson et al., 2017) compared to other models, which may provide an added value to the study of TTs.

References are included in the original special project request.

REQUEST FOR MORE RESOURCES

For each atmospheric system, 93000 units approximately have been used using WRF and, around 600000 units have cost using the very-high resolution in HARMONIE. Considering the needed different experiments before the final simulations, that is, WRF set-up, and some proofs with different HARMONIE versions, that they have cost around 800000 units, we have also consumed additional 1900000 units in simulating the TTs. This is the reason why we have exceeded the original request. In a request for more resources, we have asked for 5500000 units that have been admitted. It is worth noting that the huge domain and very high resolution used to simulate TTs (500m with the second version of the HARMONIE model) require previous needed tasks which means additional SBUs. We are sorry but finally the system setup has utilized more resources than we originally expected. Currently, the setup has been fixed and therefore in this project step we consider that the new estimation of SBUs we may need is realistic. To sum up, we would need additional SBUs for the next year to continue simulating these TTs at very high-resolution. Thus, we are asking for 8000000 units the next year of the special project in order to carry out the analysis of TTs in an advanced climate model (PHASE 3) and further simulations at very high resolution the TTs using the future ACC projections (phase 4).